

GPS-based data collection and analysis methods for better management of recreational areas

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Introduction

Recent technological advances, such as Global Positioning System (GPS) and its wide availability can contribute to a better understanding of visitors' behaviour in recreational areas and effectively support management of those sites (Gimblett and Skov-Petersen, 2008; Taczanowska et al. 2008, Shoval and Isaacson, 2007). In this paper we give an overview of methods concerning GPS data collection, analysis and visualisation. However, the spatio-temporal data alone does not provide a fully comprehensive description of the visitors' behaviour. Therefore, the focus of this paper is to present several possibilities of integrating spatio-temporal data with additional information about recreationists. The combination of methods can be used in different thematic contexts and provide a better basis for management decisions.

Methods & results

GPS data (N=534 GPS tracks) were collected in the suburban leisure sites of the city of Vienna, Austria within the framework of three research projects: BALANCE (ASAP, 2008), I AM HERE! (Schauppenlehner et al., 2012), and CARDIO-GPS (Taczanowska et al., 2012). The projects implemented different data collection strategies ranging from a large-scale on-site data collection campaign (GPS-tracking combined with structured questionnaires) up to in-depth studies focused on a smaller number of selected individuals (GPS-tracking combined with a qualitative study on public space; GPS-tracking combined with measurements of human physical activity).

Several analytical tools have been used in order to investigate the visitors' spatial behaviour at individual and collective levels. The analysis at individual level focused on the characteristics of trip itineraries, such as route length, trip duration, velocity of movement, as well as number and duration of stops. The properties of trips, based on the GPS data, were calculated in ArcGIS, BALANCE (prototype of analytical software) and Matlab. Analyses at a collective level refer to the overall distribution of recreationists within a leisure site. In order to better understand the spatio-temporal dynamics of daily recreational use ArcGIS modules such as Spatial Analyst (density analysis) and Tracking Analyst were used. The same tool has been used to analyse the density of stops in order to identify the significance of resting places in the investigated leisure site. Table 1 gives an overview of methodological approaches used to collect and analyse GPS data in three different research projects.

Discussion and Conclusions

The reported experience with a broad spectrum of data can contribute to the on-going discussion on the value of GPS tracking for management of recreational areas. GPS-based data collection and analysis are suitable for those, who are interested in a high-resolution spatio-temporal characteristic of visitors. Such information can be used in different ways to support specific management situations. In this paper we have presented the methodologies of three recent studies dealing with GPS-tracking in outdoor leisure sites.

GPS-tracking can be successfully applied in quantitative as well as qualitative research approaches. Current technological advances and better availability of GPS allow collecting larger samples of spatio-temporal data. Different types of GPS-based devices offer more flexibility in the design of data collection process. In the presented studies, next to typically used outdoor GPS devices (Garmin eTrex), other methods such as GPS equipped PDAs (Personal Digital Assistant) or smart t-shirts with integrated GPS and other sensors were used. In future, smart-phone applications could be very interesting from the GPS-data collection perspective. Linking GPS-tracking with other methodologies delivering data about physiological, demographic, psychographic and behavioural characteristics of recreationists are necessary to provide a more complete description of leisure activities. According to our experience, the most effective approach, in terms of collecting large samples of data, was using typical GPS devices and structured questionnaires. However, qualitative methods such as the participatory multiple media approach applied in I AM HERE project, gave more comprehensive insights into understanding the driving forces of recreational behavior.

In our work we stress the importance of Geographic Information Systems (GIS) as a useful tool supporting spatio-temporal analysis of the collected GPS data. Common applications such as Google Earth can be used to have a general view of the collected GPS tracks or other geo-tagged information. However, for more detailed analysis professional tools such as ArcGIS or other dedicated applications are necessary. In case of large samples of the collected GPS tracks one can face data processing problems. In the presented studies application of standard software (ArcGIS 9.3) was possible.

Finally, GPS-tracking is an increasingly promising data collection method. There is a need for further development of data processing, analyses and visualization methods. On the one hand, detailed spatio-temporal information can be

Table I. Overview of methodological approaches and tools used to collect and analyse GPS data. Summary by three different research projects.

	BALANCE	I AM HERE!	CARDIO-GPS
Objective of the project	Creating a prototype of the BALANCE IT-system for guiding visitors and at the same time collecting and analysing visitors' behaviour	Understanding recreational behaviour of adolescents in urban public space	Measuring human physical activity during hiking
Research approach	Quantitative approach	Qualitative approach	Quantitative approach (pilot study)
Target group	Hikers	Adolescents (high school students)	Healthy hikers (students of the sport university)
Study area	Lobau, Austria	City of Vienna, Austria	Wienerwald; Lobau, Austria
Data collection methods (GPS)	GPS devices (Garmin eTrex) Mobile Guides (PDA with GPS chip)	GPS devices (Garmin eTrex)	Smart t-shirts (built-in sensors, e.g. GPS chip)
Data collection methods (additional information)	Structured questionnaires	Participatory multiple media approach (photography, video, audio and analogue documentation)	Smart t-shirts (built-in sensors measuring human physical activity)
Data analysis tools (GPS)	ArcGIS BALANCE IT-system	ArcGIS Google Earth	Matlab
Data analysis tools (linkage of GPS data with additional information)	ArcGIS BALANCE IT-system SPSS	Google Earth Webapplications	ArcGIS Matlab
Data visualisation (GPS)	ArcGIS BALANCE IT-system	ArcGIS Google Earth	ArcGIS Google Earth

used for monitoring and planning of recreational areas, on the other one it can be offered to visitors itself. This bilateral interest in GPS-based data should be further investigated and eventually considered in planning future visitor monitoring campaigns.

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